ECOFISH Work Package 1: Stock assessment in the BCC region

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Timeframe: 2011-2015
Work Package linkages

Experience based knowledge

WP3 Shareholder knowledge & acceptance

WP2 Data based scientific knowledge

Catchability
Stock structure
Growth
Trophodynamics

WP1 Model based scientific knowledge

Stock assessment I
Stock assessment II

WP4 Training

Capacity building

WP3 Decision support tools
Work Package linkages

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- Stock assessment I
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- Capacity building

Experience based knowledge

“Fishermen”

“scientists”

Presentation by Astrid
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“Fishermen”

“Scientists”

Presentations by Barbara, Kelsey

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Presentation by Astrid

Our talk
Objectives of WP1

Improve reliability of stock assessments through using alternative models for processes, such as selectivity, growth and considering species and stock structure.

Establish improved statistical stock-assessment methodologies that take due account of the data available.

Establish trans-boundary assessment models that could provide a basis for regional management advice.

Target species:
   Hake
   Horse mackerel
   Sardinella
Workplan WP1

- **Task 1.1**
  - Set up of state space assessment model (SAM) for hake
    → here update from 2011 presentation
  - data compilation for transboundary analyses, review of data, data compilation procedures, e.g. split of species
    → Report on compilation of hake data for trans-boundary analyses (workshop Nov. 2011)
    → Methodology for splitting hake species established by Johnsen & Kathena (2012), split for Namibian hake before 1998 pending

- **Task 1.2**
  - Modify SCAA assessment model for SA hake to a spatial-box model with movement
    → here first indicative results

- **Task 1.3**
  - Compilation of stock assessment data for horse mackerel (incl. transboundary aspects) and sardinella, inclusive relevant quality measures
    → In progress, utilised for first Namibian horse mackerel SAM assessment
Introduction to state space assessment modelling (SAM)

**States** are the variables that we don't observe, e.g. stock sizes, fishing mortality rates

**Observations** are the variables that we do observe, e.g. catch and survey catch rates

**Parameters** are survey catchabilities, stock-recruitment parameters, process and observation variances

**Method** has not been more frequently used in stock assessment, as software to handle these models has not been available

**Application** increasingly used in ICES as standard stock assessment model (for model comparison see WKADSAM Report 2010, ICES CM 2010/SSGSUE:10) incl. extensive coursework
State space assessment model (SAM)

Model:
- Build upon classical standard equations for stock, catch and survey indices
- Extension to full parametric statistical models with model fitting based on maximum likelihood estimation
- Estimation of uncertainties an integrated part of model and unobserved random variables included
- Low number of model parameters

Example: fishing mortality (F) at age as a random walk with yearly variance (σ), → only one parameter (σ) to be estimated and F's for all years are predicted once the parameters are estimated
→ replaces the idea about shrinkage as tool to fix lack of information on last years F in classical VPA type assessments (more objective tuning)
- Nicely handling of missing observations
### Advantages compared to other assessment models

<table>
<thead>
<tr>
<th>Feature</th>
<th>Deterministic standard models</th>
<th>Parametric statistical models</th>
<th>State-space model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportionality to catch</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observation noise included</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Transparent model</td>
<td>No</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Objective model tuning</td>
<td>No</td>
<td>Can be done</td>
<td>Yes</td>
</tr>
<tr>
<td>Over-parametrized</td>
<td>Some times</td>
<td>Often</td>
<td>Can be avoided</td>
</tr>
<tr>
<td>Output includes uncertainty</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Present assessment model for hake in South Africa: Statistical Catch at Age (SCAA) model (Rademeyer et al. 2008); in Namibia an age-structured production model, being a simpler version of the SCAA (Kirchner 2011) → fully state of the art for a parametric statistical model!
**Why a new model?**

SAM is easy to use, e.g. less tuning and estimation outside the model necessary.

SAM has some technical advantages with respect to evolving selectivity by commercial fleets (modelled otherwise period specific) and missing data handling.

SAM is potentially easier to transform into a spatially explicit stock assessment model.

SAM comes along with a web-interface which allows utilisation without being "the" stock assessment expert.
Web interface for SAM

Possible for all involved to:
- see all details of the implementation
- run the assessment
- experiment with data
- experiment with model assumptions
- everyone is running the same version and uses same data
- makes update assessment very easy

Let's look to preliminary output for Namibian hake and horse mackerel partly done from here by Henrik and me (mid level user with limited knowledge) presented are standard outputs, no specific advanced analyses!
SAM test application for Namibian hake (update from last year)

Includes now for tuning:
- Summer survey
- Winter survey
- Namibian commercial trawler fleet (new)

other input, e.g. natural mortality, weight at age, maturity at age as in Kirchner et al. (2011a)

Results quite stable, but inclusion of additional survey has not reduced uncertainty

Fits to 400-500,000 to exploitable biomass as in State of fish stock reports 2011 and 2012
SAM test application for Namibian hake (update from last year)

Spawning stock biomass

Fishing mortality (ages 2-4)

Residuals observed and modelled catches

Relative high residuals in young age groups explains confidence limits in F
SAM test application for Namibian hake (update from last year)

Spawning stock biomass

- Incl. 95% confidence intervals

Fishing mortality (ages 2-4)

- Lack of catch at age, can be handled
- But results more uncertain!

Residuals observed and modelled catches

Solid circles: model overestimation
Retrospective pattern

Excluding successively recent data and re-run the assessment gives:

- an idea of the assessments stability
- potential biases of under- or over-estimating stock size and fishing mortality

Assessment is quite stable and does not show retrospective bias!

Next steps
- Split of species in catches to establish species specific assessments
- Preparation of transboundary assessment data (catch at age, commercial fleet and surveys)
- Incorporate WP2 results on catchability, growth and natural mortality as they get available
SAM test application for Namibian horse mackerel

Input data as in assessment by Kirchner et al. (2011b)

Specifics:
Age splitting of commercial fleet indices based on age structure of landings (no discards are assumed)
Applying average age structure of 1991-94 to total landings in the period between 1987-90
Natural mortality: 0.45
Fishing mortality: average age groups 3-5
The mean weight at age for the stock in all years calculated from a Von Bertalanffy growth equation based on 2004 data only
Commercial fleets included: Namibian, Bulgaria, Poland; Romania and USSR
→ Consistency check
Consistency check of tuning fleets

Abundance in a cohort from one age to the next as picked up by two successive surveys.

Catchability or age reading problems?

- Namibian
- Poland
- Bulgaria
- USSR
Consistency check of tuning fleets

USSR

Bulgaria

Namibian & others

Poland

Consistency check of tuning fleets
Spawning stock biomass, fishing mortality and recruitment

- Spawning stock biomass
- Fishing mortality (ages 3-5)
- Recruitment (at age 1)

Residuals of modelled vs. observed catches

Broad 95% confidence intervals!
Retrospective pattern

Excluding successively recent data after and re-run the assessment gives:

- an idea of the assessments stability
- potential biases of under- over-estimating stock size and fishing mortality

Assessment tends to underestimate fishing mortality and recruitment!

Reasons need to be checked
SAM output – Namibian hydroacoustic survey included

has impact on most recent years estimate
does not explain retrospective pattern (changes in opposite direction)
however, narrows confidence intervals in most recent years, makes the assessment more certain!
SAM application for horse mackerel

Next steps:

- Consolidate
  - catch at age, including catches off SA and Angola (excluding T. tracae)
  - weight at age
- Test robustness against different natural mortality assumption (and other uncertain input)
- Check for reasons of retrospective pattern
- Test for inclusion of bottom trawl survey results
- Include Nansen transboundary surveys
SAM application for horse mackerel

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Spatially structured stock assessments

Current assessment treat species as homogeneously distributed.

**Needed**
spatially explicit assessment models needed (last year introduced GeoPop, this year first attempt of a spatially structured SCAA model).

**Assumption in present SCAA assessment**
Different age/length structure on the west and south coasts reflect different fishing selectivities-at-age for the commercial and survey fleets, combining both gear and availability effects.

**Assumption here**
Survey and commercial fishing selectivities-at-age are the same across all regions and regional differences in catch age/length distributions are related to different proportions of each age class.

**Approach**
Hake modelled to move across regions through use of movement matrices, estimated for three groups of age classes: 0-1, 2-4 and 5+, assumed to be constant over time.
Spatially structured stock assessment for SA hake: an initial attempt

The model is fitted to:

- recent CPUE and survey abundance indices (region- and species-specific)
- historical CPUE (species aggregated but disaggregated for some regions)
- commercial catch-at-age and catch at length data (species aggregated and aggregated over some regions)
- survey catch-at-length data (region and species specific)
- (in the future to age-length keys as well)

Otherwise the set-up corresponds to the standard assessment (see Rademeyer, 2011).
Spatially structured stock assessment for SA hake: an initial attempt

Results are preliminary (e.g. too much capensis at the West coast in deep water)
Model needs further development, specifically with respect to handling regional selectivity differences!
Summary

SAM offers a flexible, easy to use, full statistically based dynamic stock assessment model.

Has been developed into a relatively simple assessment model, which appears to be applicable to hake and horse mackerel in the Benguela system.

Results fit to earlier assessment and survey results, but can be improved both:
• technically (e.g. changes in catchability in hake, retrospective bias in horse mackerel),
• with respect to input data (e.g. species split, inclusion of available surveys, but also biological input such as weight at age and natural mortality)

Would be best within the frame of a BCC stock assessment working group, coupled also to training and capacity building (WP4).

SAM comes with a web application allowing to run stock assessments incl. exploratory runs with various combinations of input by none assessment model specialists.

Development of fully spatially explicit assessment models handling also mixed and transboundary stocks has started, both on basis of the standard SCAA and SAM, but quite some way to go.
Thank you for listening !